European synchrotron radiation facility upgrade beamline UPBL6 – inelastic scattering

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Poster paper

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As part of phase 1 of the European synchrotron radiation facility (ESRF) upgrade programme, a new beamline (UPBL6) for the study of electronic excitations using inelastic scattering and emission spectroscopy will be designed and constructed. The new beamline will provide an intense stable X-ray beam at two different spectrometers to be used on a time-shared basis. One of the spectrometers will be dedicated to resonant inelastic X-ray scattering (RIXS); the other to X-ray Raman spectroscopy (XRS). This beamline is currently (June 2010) in the design phase and may be fully operational by early 2013.

1. Optical design

The optical design is based on the following constraints:

(*a*) energy tunability over the range 5–20 keV;
(*b*) energy resolution tunability from 1 eV to 50 meV;
(*c*) maximizing the flux at the sample, i.e. using the full X-ray beam;
(*d*) a focal spot size of <10 μm;
(*e*) allowing 200 mm around the sample for bulky sample environments;
(*f*) a fixed position of the X-ray beam at the sample.

This has led to the optical design shown in figures 1 and 2. The first optical element, CM1, is a 1 m long water-cooled white beam cylindrical mirror that collimates the beam in the vertical direction which is essential for optimizing the throughput of the high-resolution four-crystal monochromator (FCM). This mirror provides power cut-off and low-energy band pass filter for harmonics rejection which reduces the heat load on the silicon (1,1,1) liquid nitrogen (LN_2) cooled double crystal monochromator (DCM). The heat load effects due to thermal deformation of the CM1 mirror and the DCM first crystal from the intense X-ray beam from a 6 m long undulator source are both being calculated using finite-element analysis and investigated experimentally so as to achieve optimal performance. The four bounce post-monochromator, FCM, will have at least two sets of crystals with varying reflection orders for selecting the required energy resolution. Dynamically bent toroidal

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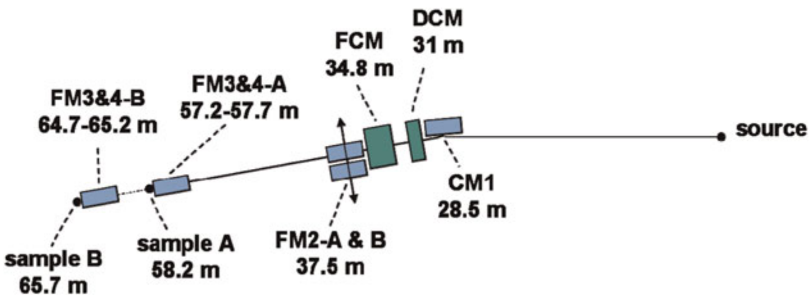

FIGURE 1. UPBL6 general layout principle (top view). The mirrors are in blue and the monochromators in green. For example, in this figure the FM2-A mirror is used for an experiment in the UPBL6-A station (sample A). The numbers are distances from the source.

mirrors FM2-A and FM2-B are alternatively used for experiments at stations UPBL6-A and UPBL6-B, respectively, and they focus the beam at secondary source points. Focusing mirrors FM3&4A and FM3&4B are two pairs of dynamically bent elliptical mirrors in kirkpatrick baez geometry, and are alternatively used for experiments at stations UPBL6-A and UPBL6-B, respectively. Their function is to refocus the beam from the secondary source to the sample stage. A focal spot size of 16×8 μm^2 $(H \times V)$ has been predicted using SHADOW software.

2. Spectrometer design

The new beamline will feature two separate spectrometers optimized for different scientific tasks:

(*a*) high-resolution (50–200 meV) spectrometer (figure 3);
(*b*) large collection angle (300–1000 meV) Raman spectrometer (figure 4).

Both spectrometers are multiple analyser crystal instruments and are based on the symmetric Rowland-circle geometry with spherically bent analyser crystals. The analyser crystals will be in Si and Ge, and will be either in bent wafer or diced

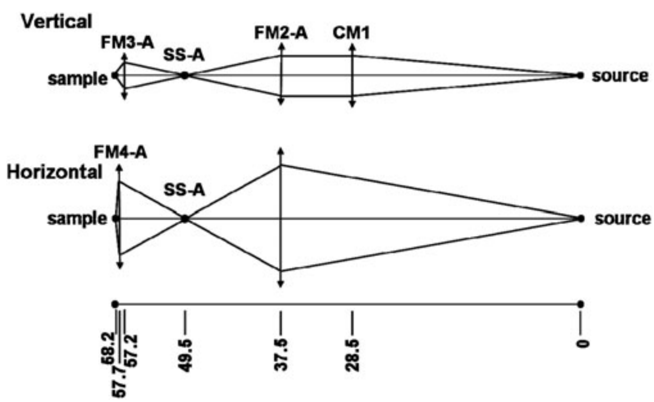

FIGURE 2. UPBL6-A optical layout principle. The vertical configuration is presented at the top of the figure, the horizontal one at the bottom of the figure. Distances from the source are in metres. The monochromators are not drawn here, for clarity. Note that for UPBL6-B the optical layout principle is the same but with slightly different distances.

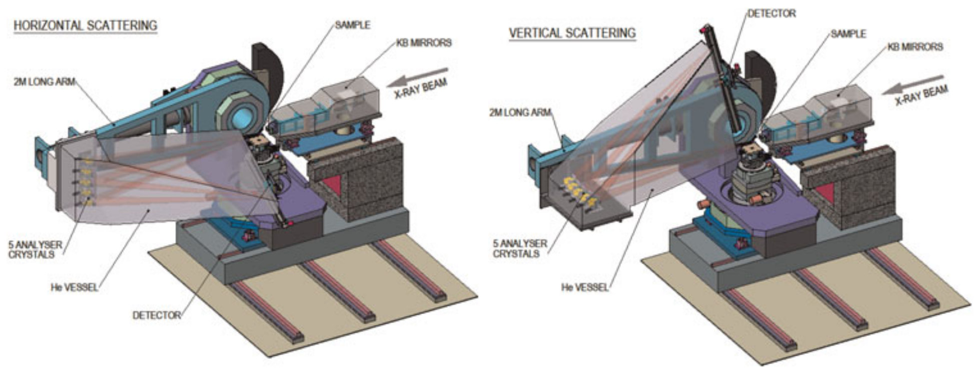

FIGURE 3. Conceptual design of the high-resolution spectrometer.

form, and many different reflection orders are foreseen. The analyser crystals are being continually developed at the European synchrotron radiation facility (ESRF) to provide improved resolution and smaller focus size.

The high-resolution spectrometer can be used for either resonant or non-resonant inelastic X-ray scattering (IXS) experiments. It has a 2 m long arm capable of rotating in both the horizontal and vertical planes up to 150°. It also has the option of operating either with a horizontal or a vertical scattering geometry, and a variable crystal Bragg angle between 90° and 70° for energy scanning. An assembly of five analyser crystals with either a 1 or a 2 m radius can be mounted on the 2 m long arm. Each analyser has its own three-axis goniometer for alignment and energy scanning. The detector is an ESRF Maxipix multi-pixel position sensitive detector and is mounted onto a 1 m long translation stage to follow reflected beams from the analysers. A large helium vessel fills the sample–analyser–detector space. The

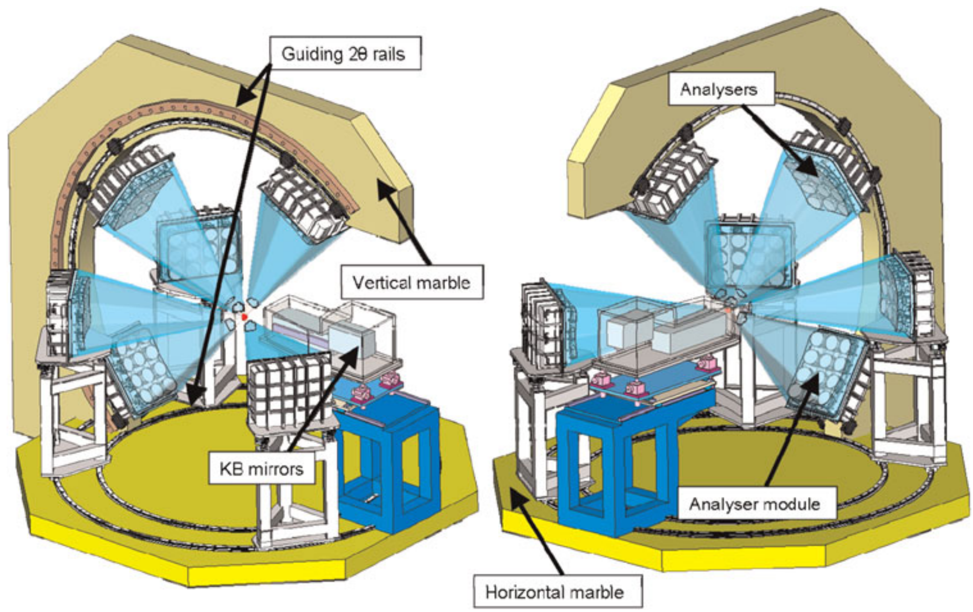

FIGURE 4. Conceptual design of the Raman spectrometer.

sample is mounted onto a six-axis goniometer tower in the centre of rotation of the spectrometer.

The Raman spectrometer has six individual modules of 12 analyser crystal assemblies; three modules are capable of rotating in the horizontal plane and three in the vertical plane. The aim of the design is to concentrate a large number of analyser crystals in well-defined, but variable, positions. All the analysers have a radius of 1 m and a non-scannable Bragg angle close to 90°, and each analyser has its own three-axis goniometer for alignment. Each module has its own ESRF Maxipix detector and a lightweight vacuum vessel.